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van Haag

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(54) **ROLL**

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(58) **Field of Search** 165/272, 90, 89, 165/104.22, 104.21; 492/46; 34/124

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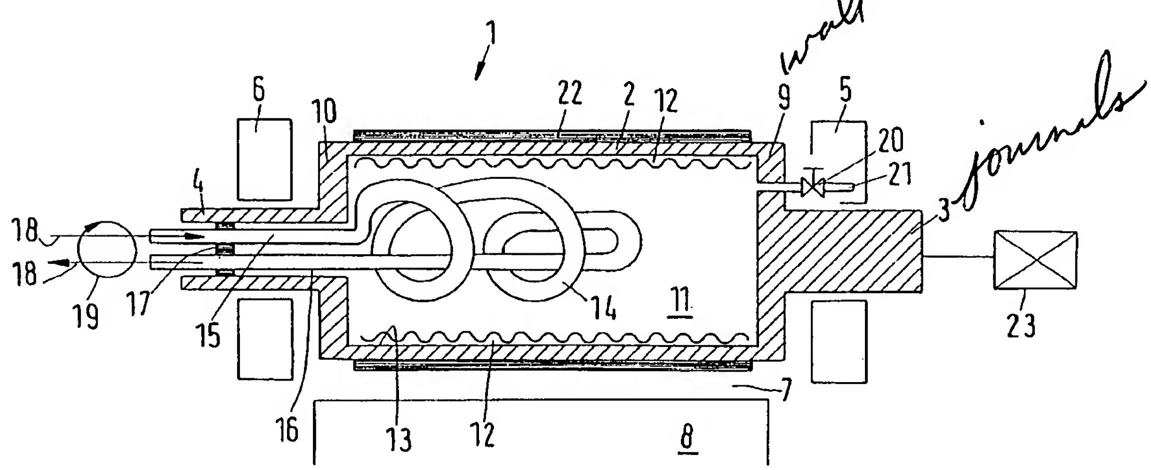
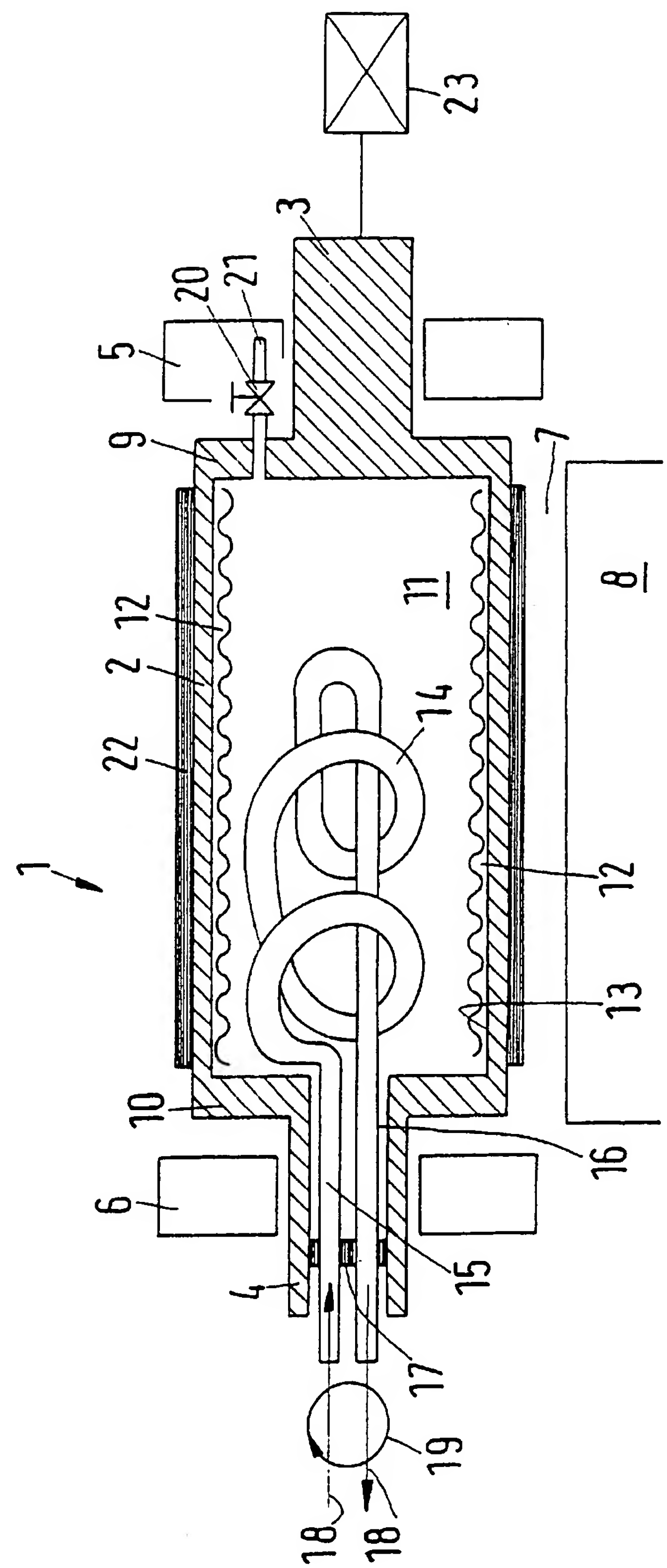
(57) **ABSTRACT**

Soft roll that may include a roll tube having an outside surface and a sealed interior space, and an elastic coating provided on the outside surface. The sealed interior space may include a vaporizable liquid and a heat exchanger for cooling heat generated in the roll during use. The sealed interior space may be gas-tight and the temperature of the heat exchanger may be set to condense vaporized liquid.

32 Claims, 1 Drawing Sheet

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ROLL

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims the priority under 35 U.S.C. §119 of German Patent Application No. 196 24 737.3, filed on Jun. 21, 1996, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

1. Field of Invention

The present invention relates to a roll that includes a roll tube provided with an outer elastic coating. The sealed interior space may include a vaporizable liquid and a heat exchanger for cooling heat generated in the roll during use. The sealed interior space may form a closed system in which the heat in the roll tube may vaporize the vaporizable liquid and the heat exchanger may be set to condense the vaporized liquid.

2. Discussion of Background Information

Rolls of the type generally described above may be utilized, e.g., in supercalenders or soft calenders. Due to the elasticity of their surfaces, these rolls are often also referred to in the art as "soft" rolls. In use, the soft rolls and so-called hard rolls are positioned together form a nip though which, e.g., a material web is conducted to smooth the surface of the web by applying pressure and, if necessary, at an elevated temperature.

During operation, the surface of the soft roll heats up due to, e.g., the flexing work performed by the elastic coating. The resulting high temperature endangers the elastic coating which drastically reduces the roll's protection against destruction.

When a roll tube is utilized as a roll jacket, e.g., in a deflection adjustment roll or deflection compensating roll, the roll jacket is supported by a hydrostatic or hydrodynamic supporting elements. In this manner, heat can be dissipated by providing hydraulic oil in an interior space of the roll. This method for stabilizing the roll temperature, which occurs like a secondary phenomenon with deflection adjustment rolls, however, is relatively costly.

Further, it is known to provide peripheral bores in the roll jacket of "hard" rolls so as to enable a through flow of a heat carrier or coolant, e.g., through peripheral channels extending through the peripheral bores. The heat absorption or emission of this medium, however, must be maintained within relatively close limits so as to prevent an irregular temperature distribution across the width of the roll. In a cooling process, as coolant flows through the peripheral channels, the temperature of the coolant may generally only be allowed a maximum rise of 1° C., and never more than 2° C. Thus, this cooling process requires an adequate volume of coolant.

There is also a possibility of cooling the rolls from the outside, e.g., by blowing with cool air or spraying with cooling liquid. However, these possibilities for cooling the rolls are somewhat limited. In particular, when spraying with a cooling liquid, there is a risk that the cooling liquid may also contact the web being processed, which may adversely affect the intended finishing of the web.

SUMMARY OF THE INVENTION

Accordingly, a particular feature of the present invention may be directed to cooling a soft roll in a simpler manner than that disclosed in the prior art.

To achieve this above-noted feature, a roll may include a roll tube that has an elastic coating provided on an outside of the roll tube. The roll tube may include a sealed interior space within which a vaporizable liquid and a heat exchanger may be positioned.

In operation, the roll and roll tube may rotate. As a result of centrifugal force generated by the rotation of the roll, the liquid provided within the interior space may be pressed against an inside wall of the roll tube to form a liquid film. For practical purposes, an adequate volume of liquid should be provided in the interior space so that a closed film may form that has a thickness of, e.g., several millimeters. Further, heat may be transmitted to the liquid, e.g., from the outside of the roll, i.e., through the roll tube. The transmitted heat may vaporize the liquid to produce steam. The vaporized liquid or steam may contact a heat exchanger so as to withdraw or emit the heat from within the interior space. The steam may then condense or precipitate on the heat exchanger. The condensation, through the centrifugal force, may be forced toward the wall of the interior space, i.e., the inside surface of the roll tube. Thus, the cooling cycle may start over again.

The present invention produces an intensive cooling of the roll tube through relatively simple measures. For example, as the liquid film located on the inside of the roll tube develops evenly, i.e., as a result of the centrifugal force, a similar even heat dissipation may also be produced. Thus, an even temperature can be maintained with good feed across the axial length and circumference of the roll tube.

In a preferred embodiment, the temperature of the heat exchanger may be reduced to a temperature below the condensation temperature of the liquid. As a result, the steam may not only be condensed or precipitated on the heat exchanger, but the condensation may also be additionally cooled. Thus, this embodiment may produce an even greater temperature difference between the roll tube and the heat exchanger. Thus, because the heat exchanger may dissipate a large volume of heat, improved heat dissipation may be achieved through the present invention.

In another preferred embodiment, the interior space may be gas-tight so that no coolant may be lost. Further, the present invention may utilize water as the coolant. Alternatively, other liquids, e.g., those exhibiting a low boiling point, may be utilized as the coolant for the present invention. Accordingly, the ordinarily skilled artisan may set certain temperature limits within which the roll tube may be heated by selecting an appropriate coolant liquid, i.e., according to its boiling point.

In another embodiment of the present invention, the roll may be provided with journal bearings. Further, the interior space of the roll tube may be closed off or defined at the axial extremes of the roll tube by respective journals and associated components or walls. This arrangement may produce a gas-tight interior space. While typical journal bearing rolls of the prior art are generally characterized by a very low dead weight that results in a desired steep characteristic curve in the calender, by utilizing an additional heat exchanger in accordance with the present invention, the roll may be cooled by simple coolants. Thus, flexing work performed in the elastic coating may have no negative effects with respect to the roll temperature and, therefore, reduce the danger of damaging the coating.

In accordance with the present invention, the heat exchanger may jointly rotate with the roll tube. This embodiment may facilitate the sealing of the heat exchanger against the roll tube. That is, if the heat exchanger is jointly mounted

with the roll tube, the interior space may be maintained stationary so that none of the gaps between the components have to be sealed. Further, the rotating heat exchanger may produce a better distribution of the liquid that is precipitated on the heat exchanger. Drops of liquid formed from the steam, i.e., which have precipitated at the heat exchanger, may be centrifuged against the wall of the roll tube where they can be revaporized. Thus, this feature of the present invention may act as a kind of pump within the coolant cycle.

In another preferred embodiment of the present invention, a flow of coolant may be fed to the heat exchanger. The application of coolant may be a relatively simple method for dissipating heat from the interior space of the roll tube. It may also be possible to use electrical components having negative temperature coefficients. However, the expenditure for dissipating volumes of heat may be relatively high. The coolant may be heated relatively fast in the heat exchanger. However, in contrast to the prior art, the present invention is not limited to allowing heating by only 1° C. or 2° C. Further, the cooling liquid may increase by 10° C., 20° C. or to an even higher temperature. As the temperature of the cooling liquid increases, a correspondingly lower flow volume of cooling liquid through the heat exchanger may be required for dissipating the same volume of heat. Thus, in accordance with this particular embodiment of the present invention, there may be substantially no risk of an uneven temperature distribution developing in the roll tube.

At least one of the journals of the roll tube may be provided with a rotary feeding device, which may be any conventional type rotary feeding device. As this arrangement requires conveyance or flow of liquids, the difficulty associated with sealing this arrangement may be less complicated than when a conveyance of gas is utilized. The rotary feeding device may be arranged at a side or an end of the heat exchanger which is not connected to nor within the interior space. In this manner, the present invention does not risk allowing gas or steam to escape from the interior space through the rotary feeding device.

The heat exchanger may be formed, e.g., as a helical tube which may enable the heat exchanger to extend over a certain area along the axis of the roll tube. The surface available for the heat exchange, i.e., between the coolant fed through the heat exchange tube and the steam contained within the interior space may be enlarged by a simple method.

Further, an evacuating device may be provided in the interior space to reduce the pressure within the interior space. Consequently, the release of pressure correspondingly reduces the boiling temperature of the liquid contained in the interior space. Thus, the pressure may be adjusted to influence the temperature of the roll tube. For example, as the boiling temperature of the liquid is lowered, the faster the liquid evaporates. Since the largest volume of heat may be "consumed" during evaporation, the temperature of the roll tube may be located with good feed in the vicinity of the liquid boiling point in the interior space.

The elastic coating may be made of, e.g., plastic. Further, epoxy resins may also be considered as appropriate synthetic materials, and plastic coatings have been developed that exhibit a high degree of elasticity.

Preferably, a roll rotary drive may be provided for driving the roll tube. The roll rotary drive may enable rotation of the roll, even when no web is being guided through the nip, or when the nip is not yet closed. In this manner, the liquid film may form at the inside of the roll tube prior to initiating the actual calendering operation, so that the cooling may start immediately.

The present invention may be directed to a roll that may include a roll tube having an outside surface and a sealed interior space, and an elastic coating provided on the outside surface. The roll may also include a vaporizable liquid and a heat exchanger that may be positioned within the sealed interior space.

According to another feature of the present invention, a temperature of the heat exchanger may be set to a temperature below a condensation temperature of a vaporized portion of the vaporizable liquid.

According to another feature of the present invention, the sealed interior space may be gas-tight.

According to still another feature of the present invention, the roll may also include journal bearings, journals, and walls. At least one of the journals and the walls may close axial extremities of the interior space.

According to a further feature of the present invention, the heat exchanger may jointly rotate with the roll tube.

According to another feature of the present invention, the heat exchanger may include a coolant supplied from outside of the roll tube. Further, a rotary feeding device may be associated with at least one journal to supply the coolant.

According to a still further feature of the present invention, the heat exchanger may include a helical tube.

According to yet another feature of the present invention, the roll may also include an evacuating device coupled to the interior space.

According to another feature of the present invention, the elastic coating may include plastic.

According to still another feature of the present invention, the roll may also include a roll rotary drive.

The present invention may also be directed to a calender roll that may include a roll tube including a gas-tight section and the gas-tight section including a vaporizable liquid and a heat exchanger.

According to another feature of the present invention, the vaporizable liquid may be adapted to form a film over an interior wall of the gas-tight section.

According to another feature of the present invention, the heat exchanger may be adapted to receive condensed vaporized liquid.

According to a further feature of the present invention, the roll may include a journal and the heat exchanger may extend through the journal. Further, the journal may include a static seal and the heat exchanger may extend through the static seal.

According to still another feature of the present invention, the gas-tight section may form a closed system in which vaporizing the vaporizable liquid cools the roll tube and the heat exchanger cools the vaporized liquid.

According to another feature of the present invention, the roll may include a drive motor for rotating the roll tube and the heat exchanger may be coupled to rotate with the roll tube.

According to a still further feature of the present invention, the roll may include a pressure valve to adjustably vary the pressure within the gas-tight section.

According to another feature of the present invention, the heat exchanger may include a circulating coolant. Further, the coolant may include one of water, alcohols and hydrocarbons.

The present invention may be directed to a method for cooling a roll having an elastic coating in use in a calender. The method may include forming a vaporizable liquid film

on an interior surface of the roll, vaporizing the vaporizable liquid film to produce vaporized liquid, condensing the vaporized liquid to produce a condensed liquid, and forcing the condensed liquid onto the interior surface of the roll.

According to another feature of the present invention, the forming of the vaporizable liquid film may include rotating the roll.

According to still another feature of the present invention, the vaporizing of the vaporizable liquid film may include frictionally heating the interior surface to a temperature at least equal to a boiling point temperature of the vaporizable liquid. Further, the frictional heating of the interior surface may include forming a nip between the roll and an opposing roll and rotating the roll and the opposing roll. Alternatively, the frictional heating of the interior surface may include milling the elastic coating.

According to a still further feature of the present invention, the condensing of the vaporized liquid may include positioning a heat exchanger within the roll and circulating a coolant having a temperature less than or equal to the condensation point of the vaporized liquid through the heat exchanger.

According to another feature of the present invention, the method may also include providing a gas-tight seal to enclose the vaporizable liquid within the roll, positioning a heat exchanger within the roll, and circulating a coolant through a heat exchanger to condense the vaporized liquid. Further, the method may include rotating the heat exchanger to remove the condensed vaporized liquid.

According to still another feature of the present invention, the method may also include supplying the coolant from outside of the roll.

According to yet another feature of the present invention, the forcing of the condensed liquid may include positioning a heat exchanger within the roll and rotating the heat exchanger.

Other exemplary embodiments and advantages of the present invention may be ascertained by reviewing the present disclosure and the accompanying drawing FIGURE.

BRIEF DESCRIPTION OF DRAWING

The present invention may be further described in the detailed description which follows, with reference to the noted drawing by way of a non-limiting example of a preferred embodiment of the present invention and wherein:

The FIGURE illustrates a schematic cross-section of the calender roll in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The particulars shown herein are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for the fundamental understanding of the invention, the description taken with the drawing FIGURE making apparent to those skilled in the art how the invention may be embodied in practice.

A roll **1** may be provided with a roll tube **2** which may be arranged via journals **3** and **4** within bearings **5** and **6** in a calender (not shown in detail). If necessary, bearings **5** and **6** may be raised or lowered in the vertical direction and/or adjusted horizontally so as to selectively open or close a nip **7** with respect to an opposing roll **8**.

Journals **3** and **4** may extend from a roll-end extremity, i.e., components or walls **9** and **10**, along a central axis of roll tube **2**. Roll tube **2**, journals **3** and **4**, and walls **9** and **10** may enclose and surround an interior space **11** to provide a sealed space.

Sealed interior space **11** may be provided with or contain a predetermined volume of vaporizable liquid **12**, e.g., water. The volume of liquid provided should be sufficient, so that during operation, i.e., when the roll is rotating, a liquid film thickness of, e.g., several millimeters may be formed at or along an inside wall **13** of roll tube **2**, e.g., by centrifugal force. In the FIGURE, a vaporizable liquid film of vaporizable liquid **12** is schematically illustrated at an upper inside wall and at a lower inside wall of roll tube **2**. Clearly, the illustrated wave shaped surface is for the purposes of illustration and explanation of the liquid film layer, and the application should not be construed as limited to an undulating or sinuous film surface along inside wall **13**.

A heat exchanger **14** may extend into interior space **11**, and may be formed, e.g., as a helical tube, as shown in the exemplary drawing. Heat exchanger **14** may axially extend into interior space **11** via a certain path.

Heat exchanger **14** may be provided with connections **15** and **16** which may be conducted through journal **4**. At journal **4**, a static seal **17** may be positioned to ensure a gas-tight seal of interior space **11**, through which connections **15** and **16** may extend without compromising the sealed nature of interior space **11**. Additionally, journal **4** may be positioned, e.g., at the non-drive side or operator side, of roll **1**.

Connections **15** and **16** may be utilized to supply and evacuate coolant, e.g., as indicated by arrows **18**, through a known rotary feeding device **19**. In general, a rotary feeding device requires that components movable in opposition must be sealed, however, in accordance with the present invention, this requirement is not critical. That is, because there is no physical connection between rotary feeding device **19** and interior space **11**, there is no danger that the gas-tight seal of the interior space **11** will be compromised by the use of rotary feeding device **19**. Accordingly, rotary feeding device **19** allows the admission of coolant liquids or gases only to the interior of heat exchanger **14** through connections **15** and **16**, not to interior space **11**. The coolant flowing through heat exchanger **14** may be, e.g., water.

Further, interior space **11** may be coupled via an evacuating valve **20** with an evacuating connection **21**. Evacuating connection **21** may, e.g., be coupled to a vacuum pump and, if necessary, to a manually operated vacuum pump. Accordingly, when evacuating valve **20** is opened, the pressure within interior space **11** may be reduced. This reduction in internal pressure, therefore, correspondingly reduces the boiling point temperature of liquid **12** contained within interior space. In this manner, the boiling point temperature of the liquid utilized within interior space **11** may be varied in accordance with desired operating parameters.

An elastic coating **22**, formed of a synthetic material, e.g., epoxy resin, may be provided around an outside of roll tube **2**. During operation of roll **1**, i.e., when rolls **1** and **8** interact to treat the web guided through the formed nip, coating **22** may be milled. The milling of coating **22** may produce heat that may increase both the temperature of coating **22** and the temperature of roll tube **2**.

Further, as roll **1** rotates, a centrifugal force is created or results within roll **1** to form a closed liquid film along inside